# Journal of the Society of Arts.

*FRIDAY, DECEMBER* 18, 1868.


## Announcements by the Council.

### ORDINARY MEETINGS.

Wednesday Evenings at eight o'clock :—

DECEMBER 23.—"Description of the Electric Organ.' By HENRY BRYCESON, Esq.

### CANTOR LECTURES.

The last lecture of the first course for the present Session, the subject being "The Aniline or Coal Tar Colours," will be delivered by W. H. PERKIN, Esq., F.R.S., on Monday evening next, as follows :—

LECTURE III.—MONDAY, DECEMBER 21ST.

*Various Aniline, Phenol, and Naphthalin Colours—Application of the Coal Tar Colours to the Arts.*

Aldehyd green—Iodine green—Perkin's green—Aniline pink—Black, browns, &c.—Phenol—Picric and isopurpuric acids—Aurine, coralline, and azuline—Naphthalin yellow—Chloroxynaphthalic acid, &c.—Application of the coal-tar colours to the arts of dyeing and printing—Paper staining and colouring—Lithographic and other printing.—Conclusion.

The lecture will begin at eight o'clock. These Lectures are open to Members, each of whom has the privilege of introducing two friends to each Lecture.

Other courses are being arranged, particulars of which will be announced.

### SUBSCRIPTIONS.

The Michaelmas subscriptions are due, and should be forwarded by cheque or Post-office order, crossed "Coutts and Co.," and made payable to Mr. Samuel Thomas Davenport, Financial Officer.

## Proceedings of the Society.

### FOOD COMMITTEE.

The Committee met on Wednesday, November 25th. Present—Mr. BENJ. SHAW (in the chair), Mr. G. F. Wilson, F.R.S., Mr. W. H. Michael, and Mr. E. Wilson.

Mr. ROBERT DAVISON, member of the Institution of Civil Engineers, attended to give information on the subject of desiccation as a preservative process.

Mr. DAVISON stated that some years ago he made experiments on the application of rapid currents of hot air to the purification of brewers' casks, and the desiccation of animal and vegetable substances, some of which were communicated at the time to the Society of Arts, and were published in their Transactions.* His attention was first given to the subject in the year 1843. The importance of hot blast had been discovered in the melting of metals, and it occurred to him that impelled currents of hot air might be advantageously applied to other processes of manufacture, especially as a purifying and desiccating process. In reference to its application to the purification of brewers' casks, the question arose, in the first instance, as to the effect it would have upon the strength of the wood. He experimented on the subject, and found that, so far from deteriorating the wood, it gave increased strength to it to a large extent. He saw that impelled currents of hot air were a valuable thing which had been overlooked, and he then turned his attention to the desiccation of vegetable and animal substances. He was successful in the first instance in desiccating potatoes and other table vegetables, which were preserved for a very long time; and he afterwards operated upon a quantity of rump steaks, and by depriving them of all their moisture, they were preserved in a perfectly sweet and wholesome condition for several months. At the time he was engaged in these experiments an intelligent young man, brother-in-law to Dr. Livingstone, who was then his pupil, mentioned to him that he was doing by an artificial process precisely what the North American Indians did with their buffalo meat and venison by the natural heat of the sun in preserving their provisions, and at the same time he gave him an extract from Catlin's work on the subject. The Indian method of drying their meat was to cut it up into thin strips, which were hung upon the branches of trees for several days in the heat of the sun. The moisture was entirely evaporated. The meat was then stowed away, and would keep good for years. Salt they never used, notwithstanding the country abounded with it. What the Indians did by natural means, he did by artificial, by the employment of impelled currents of heated air. He cooked some of the steaks desiccated by this process three or four years after they had been operated upon, and they were perfectly good, and retained their flavour. After it had been soaked in water the meat recovered nearly its original bulk. In the process of desiccation nothing but the water was removed, the albumen being all retained in the meat.

Mr. MICHAEL remarked that if the effect of this process was to produce anything like the charqui with which we had hitherto been acquainted, the meat would never be in favour with the general public. Several shops were opened in London for the sale of charqui, but it was impossible to get rid of it. He would be glad to hear in what respect the meat dried by the process described differed from charqui?

Mr. DAVISON replied that the difference was very material. He had not entertained the idea of preparing meat in this way for the tables of the gentry, but his idea was to have the meat cut into thin slices, thoroughly dried, and packed away for use as we should biscuits. In this way he thought an excellent article of food might be prepared for shipping purposes, and for the poorer classes.

Mr. MICHAEL observed that although it was sold at a low price, there was a great objection on the part of the poorer classes to eat charqui.

Mr. DAVISON remarked that three or four years ago an article appeared in the *Times*, expressing a hope that some plan would be devised for desiccating meat in a better manner than had hitherto been done. The results of the process he had described were decidedly superior to any charqui that he had seen. He had long since parted with the last portion of the steaks he had experimented upon. The apparatus for desiccation was at present largely in use for other purposes, such as the seasoning of wood, the purifying of casks, &c. It was extensively used for the former purpose in the royal dock-yards. He had no doubt he should be able to make the experiment for the satisfaction of the Committee, and should have great pleasure in doing so at the earliest opportunity. The heat of the air in his experiments

* See Supplemental vol., 1832, page 145.

was 180°, but he believed the desiccation would be effected equally well at a temperature of 120°, when the albumen would not be coagulated. Practically, he found that meat dried with a current at 180° preserved its full flavour. He had experimented with the same process on poultry, and after three or four years it was perfectly sweet. The meat and poultry were kept in his office. They were seen by Dr. Copland and Mr. J. Dalrymplé, who took very great interest in the matter, and said there could be no question that meat could be preserved in that way for a very long time. The meat was cooked as steak, and not as stew. After being soaked for about four hours, the meat resumed its original bulk and plumpness, and it retained all the flavour of fresh killed meat.

Mr. E. Wilson inquired what was the percentage of moisture which was driven off by the process of desiccation?

Mr. Davison replied that a memorandum he had found stated in one case it was 51 per cent., and in another 58 per cent. He had not experimented in that way with meat containing bone. His present idea was that it was applicable only to meat in the form of steaks or strips, and not to joints of considerable bulk and thickness or containing bone. The bones remained in the poultry which he submitted to the process, and it was perfectly good in all respects. The steaks were thoroughly dried throughout the whole substance of the meat. On one occasion he desiccated some blood, which lost 82 per cent. of moisture; he had also made experiments with potatoes and milk. A few hours soaking sufficed to restore the necessary quantity of moisture to the desiccated meat. Mr. Davison added that he was not a believer in any of the plans for sending meat to this country in bulk or in joints from the colonies, either commercially or otherwise.

Mr. E. Wilson remarked that it was very important in sending meat from long distances to save half the bulk and weight by taking away the moisture, and restoring it when used here.

The Committee thanked Mr. Davison for the information he had given them.

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Mr. William Bridges Adams attended to give information on the subject of dried meats as prepared in South America.

Mr. Adams stated that he had resided a considerable time in South America. He had noticed that the meat of Chilé was of richer flavour, and more approaching that of venison than the meat of Buenos Ayres. The climate of Chilé, from its extreme dryness, was better adapted for the curing of meat than Buenos Ayres, where there was a certain degree of humidity. The cattle were driven in in herds and slaughtered. After flaying, the bones and fat were removed from the flesh, which was cut up into strips a quarter or three-eighths of an inch thick, and hung up in the full rays of the sun, and in about eight hours it was dried almost as hard as a piece of glue. It was then packed in raw hides which shrunk upon it, and kept it very tight. His experience was, that meat dried in this way would not putrify, but after a time mites were found in it as was the case in cheese. His first experience in eating this description of meat was on a journey with two English friends south from Valparaiso. They carried a supply of charqui with them, and on the first day he volunteered to cook the supper, and accordingly proceeded to cut up the meat in shreds as small as a quill, which he placed in a vessel on a fire to boil. He observed a strange grin on the face of their attendant. When he imagined it was sufficiently cooked, he removed it from the vessel, but it was as hard as india-rubber. This appeared to cause a great deal of amusement, and he laughed heartily. He then requested the man to try his hand at it, on which he removed the shreds of meat from the vessel, and, having roasted them thoroughly brown over the embers of the fire, pounded them into very small pieces on a flat stone. They were then returned to the vessel, mixed with some vegetables, and produced a most excellent mess; but it appeared that no amount of boiling would have made the meat tender or eatable without roasting and reducing the fibres. He had said that after a time mites appeared in the meat, but there was no unpleasant flavour except there was any fat left on it; and that became rancid. For all purposes of soup or stew it was a valuable article of food.

The Chairman remarked that experience in such cases showed that with the keen appetite produced by outdoor life and mountain air, food was eaten with a relish which did not exist among home populations.

Mr. Adams said that was quite true, and there were not the same faculties of digestion. The mill workers obtained little oxygen during the day. In those countries where charqui was used as a food in travelling, it was customary to have it pounded, mixed with fat, and prepared beforehand, and slipped into a sheep or goat skin like a large sausage. He had travelled upon it for two months together, and found it very good food. All they had to do was to cook it up into a soup or stew. Some of the charqui which came to London he believed was perfectly uneatable. That which he obtained was like eating bad candles, and where there was any fat it was quite rancid. The moisture would be replaced to a certain extent by long soaking, but the meat would never be restored to its original flaccid condition. He thought it would not have less flavour. He believed the Russian frozen provisions lost their flavour to a great extent. He should have supposed that considerably more than half the weight of water was lost by the drying of the meat. He apprehended that in the process of desiccating by hot air a coating would form on the outside of the meat, which would retain the moisture, and therefore he thought a comparatively slow process of drying would accomplish the object most effectually. The heat of the sun in Chilé would be from 120° to 130° or 140°, but they had a thoroughly dry atmostphere as well. The mode of preserving meat in Buenos Ayres, South America, was by partially salting, and afterwards drying, in which case the fat was used. That description of meat was rancid, and principally consumed by the negro population of the Brazils, and it was a treat to them to get some fat, but it could scarcely be considered fit for the food of civilized people. What he would suggest was, that when the meat was brought to the condition known as charqui, it should be pounded or granulated, pressed by hydraulic power into [a solid mass, and packed in iron casks, and when it was required for use should be grated out of the lump. A valuable food would thus be produced, though not altogether of the character that would be called "nice" in this country, *i.e.*, of the first quality.

Mr. Michael inquired whether Mr. Adams had seen any of the dried mutton sent from Australia.

Mr. Adams replied he had not. He advised the solid pressing of the meat to prevent mites in it. It would be preferable that the meat should be prepared in a state of powder where it was dried, and packed under pressure in iron cases for exportation. Excellent soups for ships or hospitals might be made from that preparation. It could be effected by granulating machines, and afterwards packed tightly in iron casks.

Mr. Michael asked whether Mr. Adams was aware of the fact that some very fine samples of raisins and currants had been sent to this country from Chilé.

Mr. Adams replied that he never, to his recollection, saw any currants in any part of South America; those which Mr. Michael alluded to were probably a very small description of grapes. Very fine grapes were grown in that country, and they made remarkably fine fruit when dried, which was done by hanging them on the gables of the houses. They took about two months to dry, and the most unwholesome time to eat them wa when they were partly dried. In Chilé grapes were almost always grown on irrigated land, very large and

watery. In making wine from them it was therefore requisite to throw off a portion of the water by boiling before fermenting. He thought there was no difficulty in bringing dried beef and mutton from foreign countries. He had succeeded in drying veal perfectly in his own house, which was a difficult thing to do, but it did not succeed in strips thicker than ⅛th of an inch. He succeeded in preventing the putridity of the meat even in hot weather. The objection that in drying meat the flavour was lost did not appear to Mr. Adams to be well founded. Boiled meat, however fresh, had scarcely any flavour, and boiled fowls and boiled veal were very insipid food without bacon and butter. The flavour of meat was brought out by roasting, and could be induced from dried meat as well as from fresh, and this was the reason for roasting the charqui. Soup was usually made from unroasted meat, gravy from meat partially roasted. He thought, with proper care taken, charqui might be prepared so as to be a saleable article in this country, but people would have to get rid of the existing prejudice against it, as was the case with regard to Indian corn in Ireland. The people formerly would not touch it, but it was now found to be a most nourishing kind of food, and great quantities of it were consumed not only in Ireland but in England in various forms. With reference to the Australian cooked beef which had been sent to this country in large quantities, Mr. Adams expressed a favourable opinion of it both as regards the flavour and nutritive qualities. His own family liked it so much, that on one occasion they ate it for three days consecutively in preference to any other meat. In that which he partook of there was no loss of osmazone, and it did not appear to be so overcooked as that which had been in the market more recently. Twenty years back Alderman Finnis presented him with an eight-pound canister of this meat, which was prepared in Australia for the use of emigrant ships, and not for commerce. Its cost, brought to England, was 4d. per pound, beef of very fine quality. He thought if people could obtain such a pabulum at a cheap rate they would have no objection to supply the flavouring which might suit their various palates.

Mr. E. WILSON remarked that it was possible to defer too much to prejudices on these points. He recollected, on the occasion of a lecture being given in the adjoining room upon horseflesh as human food, everyone who spoke upon it stood out for the insuperable prejudices against its being accepted as an article of food. The lecturer stated that portions of that meat had been dressed in various ways, and those who chose to do so might taste and judge for themselves. After the meeting there was a great demand for it, so that the prejudice against it did not appear to be very deeply seated.

Mr. ADAMS believed the real objection to horseflesh as a food was that, like venison, it required the addition of good sauces to make it palatable. He had no doubt that every variety of flesh fit for human food might be preserved for any length of time, as easily as Egyptian mummies, by the process of thoroughly drying, reducing to powder, and pressing into a solid mass capable of being grated when wanted for use. In this mode all the constituents of the meat were retained, which was not the case when extracts only were prepared. He did not for a moment dispute the value of extracts, but fibre was also an important element in building up living muscle; the fat there was no difficulty in dealing with in another manner—by melting and removing the gelatine. A remark had been made that the Australian process of highly cooking the meat in tins had a tendency to coagulate the albumen. It might be so, but there was a curious fact in domestic cookery which might be brought to bear on the subject. In boiling eggs in the shells, if after the boiling point was reached the eggs were suffered to cool, no after-boiling could coagulate the white. It was possible that in preparing cooked tins of meat in Australia this hint might be of value.

Mr. Adams was thanked by the Committee for his interesting information, after which they adjourned.

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## CANTOR LECTURES.

The second lecture of Mr. W. H. Perkin's course "On the Aniline or Coal Tar Colours," was delivered on Monday evening, the 14th inst. A full report of these lectures will appear in the *Journal* at an early opportunity.

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## FIFTH ORDINARY MEETING.

Wednesday, December 16th, 1868; SEYMOUR TEULON, Esq., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Armstrong, George Frederick, C.E., 37, Norfolk-street, Strand, W.C., and 10, Albion-place, Doncaster.
Campbell, George, 60, St. George's-square, S.W.
Croll, Alexander, Sussex-house, Tudor-road, Upper Norwood, S.E.

The following candidates were balloted for, and duly elected members of the Society:—

Crellin, Philip, jun., 87, Regent-street, W.
Peters, Major James, Junior Carlton Club, S.W.

The Paper read was—

## ARTIFICIAL FREEZING AND REFRIGERATION.

BY B. H. PAUL, ESQ., PH.D.

Heat and cold, which we are commonly accustomed to regard as being diametrically opposite and distinct in their nature, do not, however, present any such difference when regarded from a scientific point of view, but are merely differences in degree of a condition common to all known material objects, and represented by the term temperature. The distinction habitually made between a thing that is hot and a thing that is cold, is a distinction which has reference only to the average temperature of the human body. Thus, when we term freezing water cold, and boiling water hot, we merely express the facts that the one has a degree of temperature lower, and the other a temperature higher than that of the human body, which is about mid-way between the two. Both ice and steam possess heat or caloric, and both may have their temperature reduced by abstracting heat from them.

In most industrial operations, especially those involving chemical alteration of the raw material employed, a greater or less increase of temperature is essential for effecting the desired object, inasmuch as chemical action is generally facilitated by heat, and, therefore, the means of producing heat and of augmenting temperature have hitherto attracted far greater attention than the reverse procedure of abstracting heat and reducing temperature. But, though it is most frequently the object of a manufacturer to stimulate chemical change by increase of temperature, there are cases in which it is desirable to hinder the natural tendency to chemical change, even within the ordinary range of atmospheric temperature. For these and other purposes it is requisite to abstract heat and reduce the temperature. The natural means of effecting this object is furnished by ice, which has now become an article of commerce, and is largely employed in several manufacturing operations, as well as for purposes of domestic economy.

Prior to the year 1840 little or no ice was imported into this country, but about that time the Wenham Lake

Ice Company was formed, for the purpose of bringing over ice from a lake some distance from Boston, in the United States. This enterprise does not seem to have been very successful at first, and eventually it was found that ice could be obtained with greater advantage from Norway, whence the ice now imported into the United Kingdom is chiefly derived.

In 1864 the quantity of ice imported is stated to have been over 30,000 tons.

The amount of waste in the transport and storing of ice will, of course, depend much on circumstances of a variable nature—such as the heat of the weather and of the sea during the voyage, the season and time of storing, &c. It appears to amount to about 30 or 40 per cent. of the quantity shipped.

The price of ice has varied, acording to the season, from 18s. to 40s. and even 60s. per ton. Besides its use for domestic purposes, which cannot be very great, it is largely used in curing pork and fish, and by brewers during summer.

Altogether the consumption of ice in this country is insignificant as compared with the consumption in America, where it is considered as a necessary; and it is stated that, in the city of Boston alone, as much as 90 thousand tons a year are used.

The price at which ice is sold retail, viz., about one penny per lb., or at the rate of from £7 to £9 per ton, is a very great bar to its more general use in many instances.

The advantages experienced by the use of ice for various technical purposes, and the increased demand for it, naturally led to the question being raised whether ice could not be produced artificially at such a cost as to compete with the natural sources of supply, and in such abundance as to admit of its use being extended. Artificial refrigeration has long been practised on a small scale by means of what are termed freezing mixtures. The following table gives the composition of several kinds of freezing mixtures, together with statements of their efficacy:—

*Composition and Effects of Freezing Mixtures.*

| Ingredients. | Parts by weight. | Temperature produced, starting from 50° F. | Reduction of Temperature. |
|---|---|---|---|
| Nitrate of ammonia .. | 1 | 4° F | 46° |
| Water .............. | 1 | | |
| Nitrate of potash .... | 5 | 10° | 40° |
| Chloride of ammonium | 5 | | |
| Water ............ | 16 | | |
| Nitrate of ammonia .. | 1 | —7° | 57° |
| Carbonate of soda .... | 1 | | |
| Water .............. | 1 | | |
| Crystallised sulphate of soda ............ | 8 | 0° | 50° |
| Hydrochloric acid .. | 2 | | |

The reduction of temperature produced by these mixtures is due to the absorption of heat accompanying the solution of the salts. In like manner, mixtures of snow, or finely-crushed ice, with half its weight of common salt, or with one and a half times its weight of crystallised chloride of calcium, will give a reduction of temperature from 32° to —4° and —50° F. respectively, if the salts and the vessels in which they are mixed with the ice be previously cooled to 32° F.

Freezing mixtures of this kind are often very useful for domestic and other purposes, but they are quite unsuited for most of the manufacturing operations in which reduction of temperature is a desideratum.

In discussing the subject of artificial freezing and refrigeration, it will be convenient, in the first place, to consider in the abstract what is the nature and amount of the work to be done; and to begin, I will take the case of the production of ice.

Before doing so, however, I will endeavour to describe some of the effects of heat, and to state briefly the mode in which quantities of heat are determined, and the amounts of heat in different substances ascertained. Heat, being merely a condition of energy of material substances, cannot be weighed or measured, like the substances themselves, and therefore quantities of heat can be determined only by a comparison of the effects they produce. Temperature is one of those effects, and for a given substance, the amount of heat which it contains is proportionate to the temperature. Thus, when, in ordinary language, we say a piece of iron at 100°Fahr. is hotter than a similar piece of iron at 50°Fahr., we correctly express the fact that the one contains a larger amount of heat than the other. But this would not be true of equal quantities of iron at 100°Fahr. and water at 50°Fahr., nor would the differences of temperature indicate in either case the proportions between the actual quantities of heat in the substances; for equal quantities of heat do not always produce equal differences of temperature, either in different substances or in the same substance.

There are also other effects of heat besides changes of temperature, and substances may contain heat in considerable amount without its having any influence on their temperature. This is termed latent heat, in contradistinction to the heat to which temperature is due, that being termed sensible heat, and it is heat in this latent condition which determines the liquid and vaporous states of substances. Thus, for instance, when a pound of ice is immersed in about three-quarters of a pound of boiling water, the ice gradually melts, and is converted into the liquid state. At the same time the water will be cooled down to 32°Fahr. In this case the amount of heat absorbed, or expended in effecting the liquefaction of the ice is about three-fourths that corresponding to the interval of temperature between 32° and 212° Fahr. Again, if steam at 212° Fahr. be forced into water at 32° Fahr. it disappears, and is converted into the liquid state, or, as it is commonly termed, condensed, the temperature of the water rising gradually until it reaches 212° Fahr. The increase of temperature in this case is due to the liberation of heat by the steam condensed; and if the weight of the water be ascertained, it will be found about one-fifth greater than it was before forcing in the steam. The amount of heat liberated in the condensation of steam is therefore about five times as great as that corresponding to the difference of temperature between water at 32°Fahr. and water at 212°Fahr. In like manner, if ice be mixed with steam at 212° Fahr., the ice will be liquefied and the steam condensed, while the water resulting from these changes will have a temperature of 32°Fahr. and weigh about one-eighth more than the ice melted. Therefore the amount of heat liberated in the condensation of steam is about eight times as great as that expended in effecting the liquefaction of ice.

The amounts of heat thus abstracted from water or from steam in the liquefaction of ice, and from steam in the heating of water, are the amounts which determine the liquid and vaporous states of water, and they represent respectively the expenditure of heat requisite for converting ice into the liquid state, and water into the state of vapour.

In order to express the quantities and relative amounts of heat concerned in producing these and similar effects, it is necessary to adopt some one effect of heat as the standard of comparison. The specific heat of water is generally taken for this purpose, and it is customary to take a certain increase in the temperature of a certain weight of water, as the effect referable to the unit of heat. In this country the unit of heat is the quantity of heat which raises the temperature of one pound of water one degree of Fahrenheit's scale.

To proceed now with the subject of artificial refrigeration or ice-making.

Water at the temperature of 60° Fahr. contains an amount of heat greater than that contained in an equal weight of ice at 32° Fahr., to the extent of 170·65 heat units for each pound, so that to convert water at a temperature of 60° Fahr. into ice, it is necessary to abstract that amount of heat from it. Thus, for instance, to produce one ton of ice—taking the specific heat of water as the measure of the heat to be abstracted, and the quantity of heat necessary to raise or lower the temperature of one pound of water to the extent of one degree Fahrenheit as the unit of heat—it would be necessary to abstract from the ton of water

$$\overset{\text{Heat units.}}{62{,}720} = 2{,}240\text{lbs.} \times 28 = 60^\circ - 32^\circ$$

in order to reduce it to the temperature of 32° Fahr., or the freezing point of water. But then it would still be water, and to convert that into ice it would be necessary to effect a still further abstraction of the heat which, in the latent condition, determines the liquid state of water. That heat amounts to 142·65 units for each pound of water,* and consequently for a ton it would be

$$\overset{\text{Heat units.}}{319{,}536} = \overset{\text{lbs.}}{2240} \times \overset{\text{Latent heat of water.}}{142{\cdot}65}$$

Hence the total quantity of heat to be abstracted from water at 60° in order to produce one ton of ice is 382,256 heat units (= 319,536 + 62,720). This is a quantity of heat equivalent to the evaporation of about 3 cwt. of water at 60° Fahr. and is not more than about $\frac{1}{80}$ of the heat capable of being generated by one ton of ordinary coal.

Refrigeration, or the artificial production of ice, is, therefore, simply a manipulation of heat. In this respect it is perfectly analogous to the production of steam by heating water. Both processes consist simply in the transfer of heat from one substance to another. They are, however, reverse processes. In generating steam, heat, produced by the combustion of fuel, is communicated to water. In refrigeration, on the contrary, heat is abstracted from water, and in this process the water, which is cooled, corresponds to the fuel burnt in generating steam, or in producing any other vapour. Just in the same way that fuel in burning yields its heat to the substance vaporised, so does water in refrigeration yield its heat to some substance capable of receiving it.

Having thus defined theoretically the nature and amount of the work to be done in producing a ton of ice, so far as the reduction of temperature is concerned, I will now proceed to consider the means by which such an amount of heat may be abstracted from water.

This work is to be done within a limited range of temperature, which, for mere cooling, must not much exceed the ordinary atmospheric temperature, and, for making ice, must not much exceed the freezing point of water. Therefore, it will be necessary to consider what are the conditions requisite for its performance, and what are the characters required in the materials which for this purpose are to take the place of water in the steam boiler, and to abstract heat from the liquid to be cooled or frozen, which again corresponds to the fuel burnt under the steam boiler.

In all cases of the conversion of a solid substance into the liquid state, or of a liquid into the state of vapour, it is well known, as I have already stated, that there is always a certain definite amount of heat absorbed, or rendered latent, in such a way as not to have any influence in raising the temperature of the substance.

This is one of the means by which either the heat to which the temperature of water is due, or that which determines its liquid condition, may be abstracted and transferred to some other substance capable of undergoing a change, such as vaporisation, which involves an expenditure of heat.

The amounts of heat thus absorbed by various substances, in changing their state, are given in the following table:—

| | Latent heat per lb. | Authority. |
|---|---|---|
| | heat units. | |
| Water vapour .......... | 966·10 | Regnault |
| Gaseous ammonia ........ | 900·00 | Favre & Silbermann |
| Alcohol vapour .......... | 364·30 | Andrews |
| Ether vapour............ | 162·80 | Andrews |

Applying these data to the artificial production of ice, it will be evident that for a given weight of these substances their efficiency in abstracting heat will be in the same ratio as the amounts of latent heat in their vapours, and that the quantities of each of the above substances which would have to be vaporised, in order to produce one ton of ice, by abstracting from water 382,256 heat units, would be in the inverse ratio, as follows:—

| | lbs. | |
|---|---|---|
| Water .............. | 395·669 | to be vaporised. |
| Liquid ammonia...... | 424·728 | to be vaporised. |
| Alcohol ............ | 1,049·272 | to be vaporised. |
| Ether .............. | 2,348·009 | to be vaporised. |

Another process in which heat is expended without producing increase of temperature is the expansion of air. The amount of heat thus absorbed is at the rate of ·069, or about $\frac{1}{14}$ of a heat unit for each pound of air expanded to the extent of ·002035, or about $\frac{1}{490}$ of its volume, at 32° Fahr. By compressing air, an equal amount of heat is liberated in proportion to the degree of compression, and the temperature of the air is raised. If the compressed air be then cooled to a low temperature, and afterwards allowed to expand, so as to overcome some pressure or resistance, a part of the heat which determines the temperature of the air is absorbed or rendered latent in effecting the expansion, and thus the temperature of the air is reduced, proportionately to the degree of expansion. Thus, for instance, if one pound of air, at 60° Fahr. (= 13·093 cubic feet under normal atmospheric pressure), were compressed to 1·24 cubic feet, the quantity of heat liberated would amount to 32·44 heat units.

Then, since air requires ·169, or about one-sixth of a heat unit, to raise the temperature of one pound 1° Fahr. when the volume remains constant, the heat liberated by the compression would produce a rise of temperature amounting to 191·98° Fahr., equal to 32·44 heat units, and the temperature of the air would become 251·98 (= 60° + 191·98°). By cooling this compressed air to 32° Fahr., the quantity of heat abstracted would amount to 37·18 heat units per pound of air, and by expanding it then to say 4 cubic feet, heat would be rendered latent in this expansion, and it would amount to 7·56 heat units. This heat would be abstracted from that to which the temperature of the air, viz., 32° Fahr. was due, and that temperature would be thereby reduced to the extent of 1° for every ·169 heat unit thus rendered latent by the expansion, or in the case here supposed, to the extent of 44·72° or to —12·72° Fahr.

Every pound of air cooled to this temperature would reduce the temperature of about ·108 lb. of water from 60° to 32° Fahr., so that to cool a ton of water, from 60° to 32° Fahr., in this way, it would be requisite to compress and cool to 32° Fahr. 9·256 tons of air; and then, to convert that water into ice, it would be requisite to compress and cool a further 46·28 tons of air, or, in all, 55·53 tons, to produce one ton of ice.

It must, however, be remembered that the free expansion of compressed air produces heat as the result of

* According to the most accurate determinations by Person.

internal friction, and consequently is attended with little or no reduction of temperature.

These, then, are the means by which heat may be abstracted from water and transferred to some other substance, so as, on the one hand, to cool or freeze the water, and, on the other hand, to effect some change in which heat is expended.

If the amount of heat rendered latent by the vaporisation of any substance were the only point to be considered, in regard to its efficiency, as a refrigerating agent, it would be evident, from what has been already stated, that water would be the best material to employ for that purpose, both on account of the large amount of heat it requires for conversion into vapour, and from its being much more readily obtainable than any other substance except air. But this is not the case, for, besides the relative capability of abstracting heat in vaporising, there are other circumstances which exercise quite as great an influence in determining the practical efficiency of any material for refrigerating. In the first place it is necessary to take into account the degree of facility with which the substances are vaporised, and the range of temperature within which they can be readily converted into vapour. The relation of the above-named substances in this respect is shown by the following table, which gives their boiling points under the normal atmospheric pressure of 30 inches of mercury, and the tension of their vapours at different temperatures:—

| | | Ammonia. | Ether. | Alcohol. | Water. |
|---|---|---|---|---|---|
| Boiling point .... | | —28·66° | 95° | 172·2° | 212° F. |
| | | inches. | inches. | inches. | inches. |
| Tension of vapour in inches of mercury at | 104° F. | 463·64 | 35·81 | 5·26 | 2·16 |
| | 68° | 254·61 | 67·06 | 1·75 | ·68 |
| | 50° | 181·58 | 11·28 | ·96 | ·36 |
| | 32° | 124·52 | 7·22 | ·50 | ·18 |
| | — 4° | 55·03 | 2·66 | ·13 | — |
| | — 40° | 20·81 | — | — | — |
| | —108·76° | 9·45 | — | — | — |

It is evident from these data that the differences obtaining in this respect entirely alter the relation of the substances as refrigerating agents. In the case of water, which has the largest capability of absorbing heat in vaporizing, the normal boiling point is much too far above the freezing point of water to admit of its being applied for cooling water; while at temperatures much below the normal boiling point, the tension of the vapour—which is the measure of the capability of vaporisation—is so small that the rate of vaporisation would not be sufficiently rapid to produce the refrigeration required in making ice. The characters of alcohol in this respect are but slightly more favourable than those of water.

In the case of ether, on the contrary, the normal boiling-point is only 35° above the ordinary atmospheric temperature, and at temperatures below that point the vapour has a considerably greater tension than those of alcohol or water. Still, the tension of ether vapour, within the range of temperature of 60° to —4° Fahr. is too small to admit of its being used as a refrigerating agent without increasing the rate of vaporization, by means of an air-pump, and evaporating in vacuo.

With liquid ammonia, however, the case is very different. This substance is gaseous within the ordinary range of atmospheric temperature under normal pressure, the boiling-point of the liquid being about —29° Fahr. under normal pressure; and it requires, at ordinary temperatures, a pressure of from 8 to 10 atmospheres (117 to 150 lbs. on the square inch) to maintain it in the liquid state. At the same time, the latent heat of ammonia approaches very near to that of water, as already stated; and the tension of its vapour between 50° and —4° Fahr. is about 18 times as great as that of ether vapour. This, then, is a material possessing the characters requisite in a refrigerating agent in a degree eminently favourable to its application for that purpose. It is only necessary to reduce the pressure by which ammonia is retained in the liquid state, in order to effect its vaporization, and thus to bring into play the capacity for absorbing heat from water or any other substance to be cooled.

For making ice, therefore, the choice of a refrigerating agent lies between air, ether, and ammonia, so far as is yet known, and as any machine which will make ice will also perform the lighter work of cooling liquids or air, I shall only refer specially to those machines which have been devised for making ice.

The compression of air appears to have been the means first applied for this purpose by Dr. Gorrie in America. In this country, ether was the material employed in one of the earliest ice-making machines, viz., that invented by Harrison in 1856.* This machine was afterwards improved by Messrs. Siebe, in 1862,† who have since that time specially applied themselves to the manufacture of ice machines. An ice-machine of their construction has been in use for some months at Messrs. Truman and Hanbury's brewery.

In the meantime—during the year 1860—another machine was invented by M. Carré, of Paris,‡ in which ammonia was used as the refrigerating agent. This machine has been largely used in the South of France for effecting the crystallization of salts by cooling. In 1862 another machine was invented by Mr. Kirk,§ of the Bathgate Chemical Works, in Scotland, in which the alternate compression and expansion of air was applied as the means of refrigeration. This machine has been used in paraffin oil works, for the purpose of effecting the separation of solid paraffin from the oil, and has also been worked in Messrs. Flowers' brewery, at Stratford-on-Avon. In 1867 Mr. Reece patented an improved form of ice-machine, in which ammonia is used as the refrigerating agent; and during the present year an apparatus has been patented by Messrs. Mort and Nicoll,¶ of Sydney, in which the expansion of cold compressed air is proposed to be applied.

Several other patents have been obtained for ice-making machines and refrigerators; but those named above appear to me to be the most important and the most representative.

In order to compare the relative efficacy of the refrigerating agents as used in these machines, I will now state what would be the minimum requirements for machines capable of producing ice at the rate of 5 cwt. an hour from water at 60° Fahr. For this purpose the effective refrigeration must amount to 95,564 heat units per hour, that being the quantity of heat which 5 cwt. of water at 60° Fahr. contains over and above the heat contained in 5 cwt. of ice.

$$\overset{\text{lbs.}}{560} \times 170{\cdot}65 = 95{,}564$$

In the case of a machine worked with ether, the hourly rate of vaporisation in the refrigerator corresponding to this effect must amount to at least 587 lbs.; with liquid ammonia it must be at least 106 lbs. per hour; and with an air machine, worked as already stated, it would be necessary to compress and cool air at the rate of 14 tons an hour.

With an ether machine, the necessary rate of vaporisation must be maintained by means of a powerful air-pump worked by a steam-engine. In the air machine, also, the compression of the air requires the expenditure of considerable power. In a machine worked with liquid ammonia, on the contrary, there is no such expenditure of power requisite, owing to the high tension of its vapour at low temperatures. But it is necessary in this

* Specification No. 747.
† Specification No. 782.
‡ Specification No. 2,503.
§ Specification No. 1,218.
¶ Specification No. 3,278.

case to keep up a great pressure within the apparatus, in order to convert the ammonia into the liquid state; and there is, consequently, greater difficulty in preventing leakage from the joints, cocks, and working parts of the machine. The use of ether as a refrigerating agent is attended with great advantage in this respect, as there is no outward pressure in the refrigerator, and when efficient condensation is applied, only a very slight outward pressure in the other parts of the machine. This circumstance admits of the work being done without much loss of refrigerating material.

The expenditure of power in working the various kinds of ice-making machines has not been very accurately determined. There can be no doubt, however, that it is largest with the air machine, and least with an ammonia machine.

I shall subsequently have occasion, in speaking of the practical working of ice-making machines, to show that the ratio of mechanical work performed to useful effect produced, is, in some cases, very much greater than it is in others; but for the present purpose a comparison may be made on the above basis, leaving out of consideration, for the present, the expenditure of mechanical power required in the various machines for producing a given effect.

Hitherto I have spoken only of the amount of vaporisation required for making ice with ether or ammonia; but it will be evident that this vaporisation in the refrigerator must be accompanied by an equivalent amount of condensation in the other part of the machine; that is to say the vapour produced in effecting refrigeration must be again condensed by the removal of its latent heat, and thus rendered capable of repeating its work as a refrigerating agent. When the expansion of compressed air is applied for ice-making, water must also be used for cooling the air before its expansion. For this purpose a copious supply of cold water is required, which in the case of an ether machine, producing five cwt. of ice per hour, will not amount to less than about 500 gallons per hour, supposing the water to enter the condenser at 60°, and to leave it at 80° F.

With an ammonia machine of the same capability the requisite supply of water for cooling will not amount to less than 500 gallons per hour, and a further quantity will be required for cooling the liquors. The condensation of the ammonia gas produced in the refrigerator is, however, chiefly effected by bringing it in contact with water which is capable of absorbing and dissolving about 500 times its volume of the gas, under normal conditions of pressure and temperature. It is also by this continuous absorption of the ammonia gas produced in the refrigerator that the vaporisation itself is determined.

Kirk's air-engine is very analogous to Stirling's power-engine. It consists of a cylinder and piston fitted with a wire gauze regenerator, arranged in such a way that when the piston is moved, the air enclosed in the cylinder may pass freely through the regenerator, and give out or absorb heat from it, the air being compressed at the one end of the cylinder, and thereby becoming heated, while it is expanded at the other end, and thereby becomes cooled. The heat generated during compression of the air is removed by a current of cold water circulating over the cover at one end of the cylinder, while the cooled expanded air abstracts heat from a current of brine circulating over the cover at the other end of the cylinder.

In Mort and Nicoll's apparatus it is proposed to compress air by hydraulic pumps to the extent of from 300 to 600 lbs. on the square inch, cooling it at the same time, and then to allow it to expand freely into a jacket surrounding the vessel containing the air or water to be cooled.

The original ether machine constructed by Harrison was a rather crude arrangement though very simple, consisting of an air-pump connected with an evaporating vessel or refrigerator, on one side, and with a condenser on the other. By the action of the air-pump ether was vaporised in the refrigerator, and the vapour forced into the condenser, where it was liquefied, and then returned to the refrigerator by means of a pipe furnished with a valve. Although the fundamental principle on which this machine was based was correct, there appear to have been several serious errors made in its application, and it did not come into use in this country.

Siebe's machine is a much improved modification of Harrison's, and though differing from that only in matters of detail, it has been found to work very successfully.

Carré's apparatus for using ammonia is of a more complicated nature. Its operation is as follows—viz., a concentrated solution of ammonia in water is heated, in a vertical boiler, under a pressure of from 8 to 9 atmospheres (=100 to 135 lbs. on the square inch). The gaseous ammonia and steam produced in this boiler pass off through an ascending coil of pipe attached to the upper end of the boiler, into a tubular condenser surrounded by water, where the distillate is cooled and liquefied under the pressure above stated. This condensed liquid collects in a receiver, and thence passes into the refrigerator, at a rate which is regulated by a special contrivance.

The upper end of the refrigerator is connected by means of a pipe with a vessel surrounded by cold water, called the absorber, where the gaseous ammonia contained in the refrigerator coming in contact with water is absorbed, and thus such a reduction of pressure is produced that the liquefied ammonia in the refrigerator is vaporised, and thereby abstracts heat from water, or brine contained in tubes fitted in the refrigerator.

The solution of ammonia produced in the absorber is continuously pumped away and forced through the outer casing of a vessel called a regenerator, fitted with tubes through which hot water, exhausted of ammonia, flows from the boiler in the opposite direction. Here an exchange of temperature takes place, the solution of ammonia becoming heated, while the exhausted liquor is cooled.

The solution of ammonia thus heated is thence forced into the vessel through which passes the coil of pipe connecting the boiler with the condenser, and, while the vapour passing through the coil towards the refrigerator is cooled and partially condensed, the solution of ammonia is there still further heated, and then flows out of this vessel through a pipe connecting the upper end of it with the boiler, where the ammonia is again distilled off through the ascending coil to supply the refrigerator.

The hot liquor exhausted of ammonia flows through the regenerator in a continuous current, regulated by a valve; thence through a cooling worm surrounded by water, where its temperature is sufficiently reduced, and is then passed into the absorber, where it becomes charged with ammonia, and is then returned to the boiler as already described.

The operation of this machine is therefore continuous, as in the case of the ether machine.

In Reece's apparatus the boiler, containing water or a weak solution of ammonia, is connected with a vessel called the analyzer, consisting of a series of plates arranged one above the other within a tall columnar vessel. The steam passing from the boiler, under a pressure of eight atmospheres (= 110lbs. on the square inch), into the bottom of this vessel, comes in contact with a stream of concentrated solution of ammonia, which is continuously pumped into the analyzer at the top, and in falling from plate to plate the ammonia of this solution is converted into gas, while the steam is chiefly condensed and runs back to the boiler. The ammoniacal vapour then passes from the analyzer into a vessel called the rectifier, where the remaining steam is condensed and runs back to the analyzer, while the ammonia, passing on to a condenser surrounded by cold water, is liquefied, and collected in a receiver, whence it flows into the refrigerator.

Meanwhile a regulated current of spent liquor runs from the boiler through a long tube, called the heater, fitted with an internal set of tubes, through which the concentrated solution of ammonia is pumped into the analyzer. By this means the solution of ammonia is heated, and the spent liquor from the boiler is cooled sufficiently to be used for supplying to the absorber, into which it is forced by the pressure in the boiler, through a pipe fitted with a cock to regulate the supply. In the absorber it becomes saturated with ammonia discharged from the refrigerator, and is then pumped out into the analyzer.

It is here necessary to mention a very important feature of the ice making machine invented by Mr. Reece, since it constitutes a very great improvement on the ammonia machine employed by Carré. The improvement to which I refer consists in the dehydration of the ammonia, and in using as the refrigerating agent liquid ammonia, which is practically free from water, instead of a liquid containing 25 per cent. of water, and only 75 per cent. of ammonia, that being the refrigerating agent used in Carré's machine.

The effect of this difference upon the working of the machines is very great. Thus, for instance, in Carré's machine, the distillate passing from the boiler is separated into 95 per cent. of solution, containing 25 parts of ammonia—which, after being cooled, is used for supplying to the absorber—and 5 per cent. of a solution, containing $\frac{3}{4}$ ammonia, and $\frac{1}{4}$ water, which passes to the condenser, furnishing a distillate containing 25 per cent. of water. Then, since the ammoniacal distillate produced in the condenser contains 25 per cent. of water, and as water is capable of dissolving and retaining in solution its own weight of ammonia, at the temperature of from 22° to −40°F., produced in the refrigerator, only two-thirds of the ammonia in the distillate will be available for refrigeration, while the remaining third of the ammonia, being retained by the water passing into the refrigerator in the 212 lbs. of distillate, will be of no service for refrigeration, and this solution of ammonia must from time to time be run off into the boiler. Therefore, since a machine of the power here assumed must vaporize at the rate of 106 lbs. of ammonia an hour, it would be requisite to produce in the condenser a distillate at the rate of 212 lbs. per hour for supplying the refrigerator, since of this quantity 53 lbs. will be water, and that water will retain 53 lbs. of ammonia, leaving only 106 lbs. for refrigeration. Then, since the cooled exhaust liquor introduced into the absorber already contains 25 per cent. ammonia, it will dissolve only $\frac{1}{20}$ more of its weight of ammonia, and it will be necessary, in order to produce the above-mentioned quantity of distillate per hour, to supply at the rate of 200 gallons of this liquor per hour to the absorber, and to pump nearly one ton of ammonia solution from the absorber into the boiler against a pressure of 10 atmospheres, which will require an expenditure of power to the extent of $\frac{1}{2}$ horse-power per hour.

In the apparatus devised by Mr. Reece, on the contrary, the distillate passing from the boiler and containing 30 per cent. of ammonia is separated by the operation of the analyzer into 75 per cent. of a solution containing 5 parts of ammonia, which is returned again to the boiler, and into 25 per cent. of gaseous ammonia, which passes on to the rectifier, where it is more fully dehydrated, and thence passes to the condenser, where it is liquefied and delivered to the refrigerator almost anhydrous. In this case, therefore, $\frac{5}{6}$ of the ammonia distilled from the boiler passes into the refrigerator, and the whole of that is effective for refrigeration, so that to maintain a vaporization in the refrigerator, at the rate of 106 lbs. per hour, only 127 lbs. of ammonia has to be distilled from the boiler, while in Carré's apparatus only $\frac{1}{8}$ of the ammonia distilled from the boiler passes into the refrigerator, and of that quantity $\frac{1}{3}$ is ineffective for refrigeration. A still further advantage of Mr. Reece's arrangement consists in the use of water containing but very little ammonia, or about 5 per cent., for effecting the absorption of the gas generated in the refrigerator, and as that is capable of dissolving a further 20 per cent. of the gas, only $\frac{1}{4}$ as much as is requisite in Carré's apparatus is necessary, consequently there is only $\frac{1}{4}$ as much liquor to be pumped back into the boiler.

These are advantages of a very striking and important nature, and they offer, for the first time, an opportunity of realising to the fullest extent the great capabilities of ammonia as a refrigerating agent, in such a way that it is likely to surpass in efficiency all others.

I will now proceed to consider the application of ice-making machines, and certain conditions affecting their practical working in a general way, and to point out some remarkable differences in the results obtained with them under different circumstances. Hitherto little has been done in this country in making ice, since the artificial ice has certain defects, which for some purposes place it at a disadvantage as compared with the natural ice imported from Norway.

But apart from the actual production of ice, machines of the kind just described may be of great service for various other purposes. Thus, for instance, in breweries, though there water is a thing unknown, brewers being affected with a kind of chronic hydrophobia, it is frequently requisite to cool down large quantities of "liquor," or wort, and for this purpose ice has been largely employed. The importation of the large quantities of what may be termed waste meat from the Australian colonies, and from South America, appears to depend mainly upon a practical solution of the question whether a sufficiently low temperature can be maintained in a cargo of meat during the passage to England, at such a cost as would leave a profit on the trade. To obtain any large sale for that meat in this country it must be brought over in a fresh state; and there is every reason to believe that, if meat be kept at a freezing temperature, it will remain sweet and good for a very long time. In connection with this subject, therefore, the possibility of refrigerating, or making ice by artificial means, acquires a very great degree of interest for all who suffer from the present high price of meat in this country; and, perhaps, still more for the farmers of Australia and for shipowners, since there can be no doubt that if Australian meat could be brought here in a sound, wholesome condition, it would give rise to a great trade, and be a great benefit to all concerned.

In making ice with any of the machines already mentioned, it is impossible to effect the refrigeration of the water directly, since the apparatus would thus become blocked up with ice. It is therefore necessary to employ a refrigerating medium, which will bear cooling to a temperature considerably below the freezing point of water without solidifying. Many saline solutions possess this property, and a strong solution of chloride of calcium, or a concentrated solution of common salt, answers very well for the purpose. This solution is made to flow at a convenient rate through tubes or other spaces arranged in the refrigerator or vessel within which the refrigerating material is being vaporised, and when the temperature of the solution is sufficiently reduced, it is passed into a kind of trough, fitted with cellular metallic vessels containing the water to be frozen, and arranged so that the cold solution flowing round the outside of these cells abstracts heat from the water and reduces its temperature.

The lower the temperature to which the salt solution can be cooled in its passage through the refrigerator, the more effective it will be in producing ice, for the rapidity with which heat is abstracted from the water will be greater in proportion to the difference between the temperature of the water and that of the saline solution, which for ice-making must of course always be lower than the freezing point of water.

At the same time there will always be some waste

arising from the absorption of heat from the surrounding atmosphere by the cold saline solution, and this waste will also be greater in proportion to the difference between the temperature of that solution and the temperature of the atmosphere, so that there will probably be, in this respect, a practical limit to the reduction of temperature beyond which the advantage gained in one way would be counterbalanced by the increased amount of waste.

The actual amount of waste due to this cause is altotogether but small, and it has been very much overestimated. By carefully padding the pipes and vessels through which the cold saline solution passes, it may also be very materially reduced.

There is, however, another far more important circumstance which affects the ratio of work done to useful effect realised, and this relates to the range of temperature within which refrigeration is effected. Thus, for instance, in an ether machine, making ice at the rate of five cwt. an hour, the temperature of the refrigerating medium must be reduced below the freezing point of water, say to 14° F., and, though the vaporisation of the ether would, on the average, take place at a temperature somewhat above that point, the tension of the vapour produced would correspond to 14° F., or be equal to a column of 4·46 inches of mercury.

We have seen that to do this amount of work the effective refrigeration must amount to 95,564 heat units per hour, and that the corresponding vaporisation must be at least 587 lbs. of ether per hour. Now, contrast this case with one in which the temperature is not reduced below, say 41° F. At this temperature the ether vapour will have a tension equal to 9·25 inches of mercury, or twice as great as the tension at 14° F., and as the density of the vapour is proportional to the tension, the air pump will exhaust at each stroke twice as much ether at 41° as it would at 14° F. Consequently, at the higher temperature, the rate of vaporisation will be double what it is at the lower temperature, and the refrigeration produced in a given time will be twice as great as that produced in making ice. At the same time, the expenditure of power will be relatively greater at the lower temperature, since there will be a greater resistance to overcome in forcing the ether vapour into the condenser, owing to the greater difference between the tension of the vapour on the exhaust side of the air-pump piston and that on the delivery side, these being as 9·25 inches to 18 in the one case, and 4·46 to 18 in the other; the differences being in the one case 13·54 inches, and the other 8·75 inches.

In the case of a machine worked with ammonia, there is not this disadvantage in working at a low temperature, for although the tension of the vapour produced in the refrigerator at 14° Fahr. is only equal to 55·03 inches, or ⅓ as great as the tension at 41° Fahr., viz., 153·05 inches, the absorption of gaseous ammonia by water takes place readily even at the lower temperature; and as this is the means by which the ammonia vaporised in the refrigerator is removed, it is only necessary to control the copious supply of water for cooling the liquor by which the ammonia is absorbed, and to regulate its temperature during the absorption, in order to maintain a given rate of vaporisation, and to work with as much advantage at a low temperature as at a high one.

But in many cases where refrigeration is required, it is by no means necessary to produce ice, and, in fact, there may be a very great advantage gained by not doing so, especially when an ether machine is used, as has already been pointed out, for it must be remembered that the work to be done in cooling water to the freezing point is only one-sixth of that requisite for converting it into ice, and that in making ice five-sixths of the work required, has to be done under the greatest disadvantage, within a range of temperature below the freezing point. Thus, for instance, in curing-houses or breweries, where the object is to keep down the temperature of large enclosed spaces, or to cool down large masses of liquid to the extent of 10° or 25°, it would be possible, with a machine of given capability, to obtain a far greater amount of actual duty by direct refrigeration to the extent required, than by making ice and then using that for the purpose of cooling.

The practical recognition of this fact is a circumstance of very great importance in regard to the application of ice-making machines, so much so, indeed, that it may be said to have given an entirely different aspect to the question which would naturally suggest itself to every practical mind, whether the advantage to be gained by using such a machine compared with the original outlay, current expenses, &c., would be greater than in using natural ice.

The merit of having put to the test of practical trial the idea of applying ice-making machinery to direct refrigeration is due to Mr. King, the engineer of Messrs. Truman and Hanbury's brewery, and it is to his enterprise that those interested in the subject of artificial refrigeration are indebted for the working out of this problem. An ice-making machine of Messrs. Siebe's construction, and capable of making five tons of ice in twenty-four hours, has been for some months in operation, on this plan, under Mr. King's direction, and a most remarkably successful result has been obtained.

I am indebted to the kindness of Mr. King for an opportunity of observing the work of this machine, and for several details of the results obtained with it. Thus, for instance, when used for refrigerating "liquor," he has found that, with an atmospheric temperature of 62°, 1,000 barrels of water was cooled to the extent of fifteen degrees, or from 57° to 42° Fahr. within twenty-four hours. This result expressed in heat units amounts to

$$5{,}400{,}000 = 1000 \times 360 \text{ lbs.} \times 15 \text{ degrees.}$$

And it serves well to illustrate the advantage to be gained in certain cases by direct refrigeration, for while the machine with which this result was obtained is capable of producing only about 5 tons of ice in 24 hours, the refrigeration above referred to, is, in fact, equivalent to the production of no less than 14 tons of ice from water at 60° Fahr.

| | Heat units. | Tons. |
|---|---|---|
| Refrigeration obtained ........ | 5,400,000 | |
| Quantity of heat to be abstracted from water at 60° Fahr. in producing 1 ton of ice....... | 382,256 | = 14·126 |

I have thus far endeavoured to show how artificial refrigeration may be effected, and that by carrying the operation far enough ice may be produced. I have pointed out the means by which this may be done—the requirements of a refrigerating agent, and the chief methods which have been adopted or proposed for this purpose, and I have done so with the object of putting before you the question whether, in a general way, artificial refrigeration, or the making of ice, is or is not practicable and useful—which methods are in that respect the most advantageous, and what are the applications for which it would be useful.

In considering these questions there are many points to be taken into account, such as the consumption of fuel, power required, original cost and durability of the apparatus, which would occupy too much time to discuss this evening, and as there are many gentlemen present who have practical experience of these matters, and can speak with more authority than I can pretend to, I will not trespass longer on your patience.

## DISCUSSION.

The CHAIRMAN, in inviting discussion on the subject which had been brought so ably before the meeting, requested the speakers to bear in mind the beneficial results which might be obtained by the use of cold in the carriage of provisions to market. It was said that in America, the introduction of ice into railway vans had enabled large quantities of meat to be brought from long

distances and delivered in excellent condition, and it certainly appeared to him that it might be possible to maintain, by some of the means to which Dr. Paul had alluded, such a temperature in the hold of a vessel as would allow of meat being brought in good condition even from Australia. It was quite plain that if an ice-making machine would so reduce the temperature of a fluid flowing through pipes as to be useful for a brewer, the same machine worked in a steam vessel would keep down the temperature in the hold; at any rate this was a matter well worthy of attention. For a considerable time there had been a Food Committee of this Society sitting, and receiving evidence on the subject of obtaining a better and cheaper supply of food, and it seemed possible that by some such means as had been alluded to in the paper, the surplus food, as it might be called, of Australia, might be imported in good condition for the benefit of this country.

Mr. Botly had been rather disappointed at not hearing a reference made in the paper to the obtaining of ice by the well-known experiment of Leslie with the air-pump, which he had himself repeated some years ago, which led him to believe that further results might be looked for. He believed that in the last century a patent had been taken out by a member of the family of the Duke of Norfolk for boiling sugar in vacuo, under which condition the operation could be conducted at a temperature of 100° instead of 212°. With regard to bringing meat from Australia, it was well known that thousands of tons of good meat were annually boiled down for tallow, which, if it could be brought to England, would be of immense value. He hoped yet to see the day when ice would be much more largely used, and be rather an article of necessity than of luxury in every household, even if they were not able, as many would desire, to have skating all the year round.

Mr. Carnegie said that when they considered that the weight of fish consumed annually in London was equal to the weight of butcher's meat, and how often large supplies of fish were held back in summer time, simply from the knowledge that if it were sent, large quantities of it would have to be destroyed for the want of ice in which to preserve it during the journey and on arrival, and also how often meat had to be sold in considerable quantities at unremunerative prices, to avoid total loss, it was very evident that if any means could be perfected for producing a practically unlimited supply of ice at a moderate cost, the benefit must be immense to the community at large. It would not only tend to reduce the price of food, but also to prevent those fluctuations which did more than anything else to prevent a constant and large supply to the London markets. He should therefore like to know at what price machines could be supplied which would manufacture four or five tons of ice per day. If they could be procured at a moderate cost he had no doubt that at many places round the coast they would soon be introduced, and prevent the waste of large quantities of fish, which were now often used simply as manure.

Mr. Shand believed the means existed not only for preserving fish in any quantity for a considerable time, but also, if desired, of providing sheets of ice for skating all the summer. With regard to the prices of the apparatus by which this could be accomplished, he could supply any one who wished to know with the requisite information respecting a refrigerating machine which had lately been made in Paris, and which was actually now being applied for the purpose of refrigerating the holds of vessels, for transporting meat from Monte Video, and also for the purpose of conveying fish a considerable distance by sea. He referred to an apparatus invented by M. Tellier, which, he believed, was very similar to, but was, probably, an improvement on, that made by Harrison, to which allusion had been made. M. Tellier had a chamber of considerable size on his premises, near the Champ de Mars, which was cooled down to about freezing-point, and it could easily be reduced considerably lower, so that if any one wanted to enjoy skating all the year round, he had only to apply one of these machines to a room of sufficient size, and he could then have the floor covered with a sheet of ice. A short time ago there was a proposition in *Punch*, founded on a speech of Mr. Disraeli's, with respect to the Irish climate, suggesting that some such apparatus should be set up in Ireland sufficiently powerful to bring the climate of the country into a condition which it was supposed would be more suitable to the moral improvement of the people. He (Mr. Shand) had suggested to M. Tellier the idea of applying a refrigerating machine to cool the atmosphere of a chamber, it having occurred to him, when engaged in the construction of large ocean steamers, that any plan by which a cool atmosphere could be secured when in the tropics would be an immense advantage, not only in the way of comfort to the passengers and crew, but also in saving the waste which was continually occurring in regard to preserved provisions from the excessive heat. A machine had been placed on board a vessel at Havre, which was going to South America for the purpose of plying up and down the Amazon, and supplying fresh fish to the large towns in Brazil. Arrangements were also being made for applying the same invention to a vessel for the purpose of importing fresh meat from Monte Video, and he saw no reason why the same apparatus, or one more convenient, if it could be found, should not be applied to the importing of fresh meat from Australia. He had seen in M. Tellier's cool chamber joints of meat, both beef and mutton, and also game which had been hanging there for at least seven weeks, and after it had been removed thirty-six hours it showed not the slightest sign of decomposition. A fish after being hung for a fortnight in the cool chamber was cooked at a celebrated restaurant in the Palais Royal, together with one of the same kind purchased fresh in the market, and the company present were unable to distinguish between the two. He had himself been a witness of these facts, which he considered of great importance, especially with regard to the supply of fish to the European markets. It had been pretty well decided in France, that the fisheries on the European coast were fast being exhausted, and although the English parliamentary commission in 1864 did not quite arrive at the same conclusion, yet it was disclosed in the evidence laid before them, that on many occasions ten tons of haddock a-day had been thrown into the sea by one fishing company, for want of sufficient means of preserving it. Had one of Tellier's machines been available, such a thing need not have happened. It was true that it had not been practically tried for this purpose, but it would soon be, and he was satisfied the result would be successful, and that fish could be safely brought from Norway or from any other place within fourteen or fifteen days' sail, and probably a much longer distance. It was pointed out in the year 1840, by M. Berthelot, French Consul at Teneriffe, who quoted from a work published by a Mr. George Glass (who had navigated those seas some 150 years previously) that there was an exceedingly rich and productive fishery along the coast of Africa, from opposite Gibraltar to Senegambia, though it had never been worked except by the natives of the Canary Islands. At this spot, not only was the fish caught in greater quantity and with greater facility than off the coast of Newfoundland, but there were at least a hundred varieties, all edible, which were caught in great abundance on these banks. He believed that a boat's cargo could there be made up in two or three days, and there was also a great advantage in regard to the weather, when compared with the Newfoundland fisheries. He was anxious to draw attention to these fisheries, not only in England but in France, and he was satisfied that by the use of the refrigerating apparatus he had referred to, there would be the means of bringing an immense supply of wholesome food to London and Paris from regions yet unworked; and also of distributing the same

to the large populations in the interior of Europe, He hoped himself to be the agent, before long, of bringing something like a thousand tons a day up the Seine to Paris, and of keeping in a cool chamber a constant supply always on hand, so as to avoid the great fluctuations which were at present the rule in the fish trade. Besides the more powerful apparatus to which he had alluded, M. Tellier had also a modified form, by which he produced a cold atmosphere for a short period of time by the simple evaporation of ammonia.

Mr. FORDRED, remarking that the paper had not only referred to the production of extreme degrees of cold, but also to its applicability to various manufactures, said he thought that sugar refining was one which might have been mentioned. A great deal of water was used by the refiners in connection with the vacuum pans for condensing the steam, and the water being furnished by meter, it became a great object to prevent any waste or an unnecessary quantity being used. To this end an apparatus had been invented by a Mr. Schwartz, a sugar refiner, which could be seen in operation in Whitechapel; it consisted of a light frame-work, erected upon the roof of the refinery, formed of galvanized iron, with layers of brush-wood; the hot water was pumped up to the top and distributed in the form of spray over the brushwood, through which it gradually percolated to a reservoir at the bottom, for use again, becoming cool in the process by the action of the air. This had been found of great use, especially during the dry weather, when the sugar refiners had been put on half-supply by the water companies, and even threatened with a total stoppage for a time, though fortunately the weather changed before this extreme measure was carried out. It was possible that a cheap and simple refrigerating machine, therefore, might be of great service to sugar refiners. With regard to the freezing mixtures which had been alluded to in the paper, he had, some years ago, when in want of such a compound, consulted several works on chemistry in the hope of finding one tolerably cheap and easy of application, but most of them appeared either expensive or complicated, and some both. After some experiments of his own, he had hit upon a very cheap and simple compound consisting of muriate of ammonia and crystallised carbonate of soda (the ordinary washing soda) in the proportion of two ounces of the former and five ounces of the latter, finely powdered, to four ounces of water, which produced ice very rapidly.

In answer to a question as to what would be the cost per pound of bringing meat from Australia or Monte Video by M. Tellier's process,

Mr. SHAND said that if M. Tellier's machine were efficacious—of which he entertained no doubt whatever—the cost of working it was so trifling as to add but very little to the expense of freight. Speaking entirely without book, he should think that in a very large vessel the extra cost of the necessary apparatus and appliances for preventing the access of hot air to the cool chamber would be about a thousand pounds; at any rate, the cost would not at all stand in the way. Then they must add the wages of a man to look after the machine, and a few horse-power taken from the engines, which, in steamers of a large class, would not be very material.

Mr. FORDRED observed that Mr. Shand had not informed them of the principle on which M. Tellier's machine was constructed, or the materials used, which, he thought, would be interesting.

Mr. SHAND said he believed the principle was much the same as that of Harrison's machine. It consisted of a cylinder, very much resembling a locomotive steam boiler, but formed of cast-iron, having tubes running through it, and the air to be cooled was passed through the tubes from end to end, being forced through them by a fan. The evaporating agent by which the cooling was effected was ammonia. If such an apparatus were at hand, it would prevent any difficulty in disposing of large quantities of meat on Saturday evenings at wholesale markets. A drawing which he had seen of Siebe's improved machine, appeared very similar to Tellier's. He would repeat, in conclusion, that when once erected, the cost of keeping it in operation was scarcely worth considering in a question embracing the transport of large quantities of meat or fish in a fresh and wholesome condition.

Mr. CHARLES FLOWER being greatly interested in this matter, had come to learn what improvements had been lately made in ice machines. For the last three years he had been using a machine of Kirk's, described by Dr. Paul as a compressed air machine. Mr. Shand had laid claim to the idea of using a cold air chamber, but three years ago he had worked throughout the summer with a cool chamber by the aid of Kirk's machine. He had it erected because a cool atmosphere was of great importance to him in his business of brewing, and it had been considered a great success. When the ordinary temperature was 75°, the cool chamber could be kept at 60° or even perhaps 55°, but the difficulty he found was when the air outside was 60° to get a corresponding decrease of temperature inside. He had no doubt, however, that this would be done before long quite satisfactorily. With him it was a mere question of expense, and as soon as he found a machine which would meet his requirements at a sufficiently moderate cost, he should immediately introduce it, and he believed before long that not only in his own business, but in many others, the use of artificial cold would become quite general. He was glad to see so good a drawing of Mr. Reece's machine, which he had examined, and which seemed to him perfect in theory, but, unfortunately, there had always been some hitch in it when he had been invited to see it at work. He should, undoubtedly, introduce another machine as soon as he found out which was the best, because Kirk's, although simple and excellent so far as it went, was not sufficiently powerful.

Mr. SHAND said he believed M. Tellier guaranteed that his machines would produce ice at a cost of 8s. per ton.

The CHAIRMAN said he had been much interested both in the discussion and also in the paper itself. Dr. Paul had not proposed to give a history of ice-making machines, but probably the earliest apparatus for this purpose was that described in the second supplement to the "Encyclopœdia Britannica," published in 1818, which machine was the invention of Professor Leslie. One gentleman had alluded to the use of the air-pump, and he might add that by its aid any one could readily make ice, the operation being very simple. Under the receiver of the air-pump was placed a cup containing the water to be frozen, and around it either some well-dried oatmeal, or, what was preferable, highly-concentrated sulphuric acid. There might be any number of these receivers, from which the air might be exhausted in succession by the same air-pump. Immediately the action of the pump began to withdraw the air, vapour passed rapidly from the water, and being absorbed by the sulphuric acid or oatmeal, a dry cold air was the result. The more rapidly the vapour was taken off the more rapidly would congelution be effected. Dr. Paul had alluded to the principle, but that he believed was the sole application which had been made of it; it was stated by Professor Leslie to have been discovered by him in 1810. With regard to the application of ice or cold air to the preservation of provisions, he thought it would be very useful in cases of much shorter distances than from Australia or South America. Large quantities of cattle were supplied to England from the Continent, coming principally by way of Harwich, and it was well known that in bad weather any danger that existed was materially increased by the presence of a cargo of live stock, as they sometimes got loose, and produced serious inconvenience. If, instead of importing live cattle, the carcases could be properly prepared for the market, and imported in a cool temperature, there would be an advantage every way, for the meat would be in a much

better condition by the time it reached the consumer. Ice, or the refrigerating effects of the evaporation of ether, had been found of great assistance in dentistry and some surgical operations, in cases where local anæsthesia could be employed. He could not quite concur in the opinion of Mr. Shand, that the use of a ten-horse engine from Australia to England was an unimportant consideration in regard to cost; but from what that gentleman had said, he had no doubt that the desired effect would soon be practically attained. He begged to move a hearty vote of thanks to Dr. Paul, for his valuable paper.

The motion having been carried,

Dr. Paul said he had been in hope that some gentleman who had had practical experience of the working of ice-making machines would have been able to give them more detailed information as to the results obtained, but on that subject little more than suggestions had been made. The remarks had been chiefly confined to the preservation of food by means of ice or a cool atmosphere, and a question had been put in connection with that branch of the subject, as to the cost of the machines, but in his view the prime cost of the machine was a minor consideration, the important point being the cost of working. It was rather difficult to give details on this point, but he would put before the meeting such information as he had been able to gather. An ether machine would require the expenditure of about one ton of coal to produce three tons of ice. With the machine used by Mr. King, to which he had referred in the paper, one-eighth of a ton of coal was sufficient to produce a refrigeration equivalent to a ton of ice. Mr. Kirk's machine, on the other hand, though it possessed a most perfect mechanical arrangement, and was not liable to get out of order, required a large expenditure of power, but he had not been able to learn, either from the makers, or from Messrs. Flower, who had sent him much valuable information, what was the actual quantity of coal consumed. According to the account given by Mr. Kirk himself, he believed that to make a ton and a-half of ice per day, 23 indicated horse-power was requisite, which was a very serious matter in connection with any project for bringing fresh meat any considerable distance by sea. With regard to the ether machine, supposing they were bringing a cargo of ice of a thousand tons in weight from Australia, he thought it would, on a moderate estimate, lose by melting three tons a day, and, therefore, to counteract that and to keep the temperature to a proper degree, a machine capable of producing three tons of ice per day must be employed; and that would require a consumption of something like 100 tons of coal on the voyage, which would probably occupy about 100 days. He did not think, therefore, that the ether machine would be applicable for this purpose. Next came the use of ammonia. He must confess himself guilty of omission in not mentioning the machine of M. Tellier, who he knew used the best material, in his opinion, dry liquid ammonia, but, after hunting all the records of the Patent Office, he had been unable to find any specification, and so could not refer to it. M. Tellier, he believed, used anhydrous liquid ammonia, in the same way as ether was used for the reduction of the temperature by evaporation, and then re-condensed the ammonia by means of mechanical power. It was not necessary to use a pressure of ten atmospheres, provided the temperature of the ammoniacal gas was previously lowered, but in proportion to the lowness of the pressure, must also be the lowness of temperature, so that what was gained in one way was lost in another. There must either be a great previous reduction in temperature, or a great increase in the pressure. With the data he had given as to the tension of ammonia vapour at the freezing point, it was easy for any one to ascertain what would be the amount of power required to condense ammonia over and over again, so as to be constantly used as a cooling agent. With regard to the way in which refrigeration was to be effected, it would vary according to circumstances; air could be cooled as easily as water, and in fact more easily, for 4lbs. of air could be cooled as easily as 1 lb. of water; and while 4lbs. of air occupied 52 cubic feet, 1 lb. of water only occupied 1-62nd of a cubic foot. Therefore, the refrigeration could be applied either directly to the air or to a concentrated solution of brine, as might be most convenient, the latter, of course, being the best form for concentrating the refrigerative power, while the former would be more suitable for distributing the cooling effect over a large area. The plan Mr. Shand had referred to for applying ammonia was of this nature—a current of air being passed through the refrigerator into the chamber to be cooled, instead of a current of brine as in the process for making ice. He believed a cooling effect equivalent to the manufacture of a ton of ice per day might be produced at a total cost, including wear and tear and interest on outlay, of about ten shillings a ton. He believed that estimate was within the mark, and had no doubt but that the practical details would soon be worked out satisfactorily.

## Proceedings of Institutions.

Farnham and Aldershot Local Board.—This board held a meeting in Farnham, on Monday evening last, to bid farewell to its late hon. secretary, Mr. Barrow Rule, who is leaving the neighbourhood. Great interest was felt in this meeting, because Mr. Rule is highly esteemed by all members of the board for the active part he has taken in all its transactions for many years past, and for the remarkable success with which he has conducted its business. To record his merits, and to express the deep regret of the members at his removal, a resolution had been passed at the previous meeting of the board, and a copy of it, richly illuminated on a parchment scroll, was presented to Mr. Rule on Monday. A valedictory address, full of hearty feeling, was also given by the chairman, R. O. Clark, Esq., and to this Mr. Rule made a suitable reply. The secretary is now Mr. George Dewdney, B.A.

## THE USE OF PRIZES AT INTERNATIONAL EXHIBITIONS.

Mr. E. L. Beckwith, in his Paris Exhibition report on Fermented Drinks, expresses his opinion on the above subject as follows:—

With regard to prizes, I hold medals, certificates, mentions, &c., to be legitimate instruments for good. That they may occasionally subserve the purposes of trade advertisement is a matter unworthy of notice, and one with which the donor at least has nothing to do; but they are of great value as an encouragement to industry and a recognition of merit. I may observe that many judicious friends of education have deprecated the prize system in schools, on the ground that undue emulation is thereby encouraged. Such objections do not hold with regard to trade and manufacture. There emulation cannot be too constant or too vigorous. The community is benefited in the end by increased cheapness and increased excellence.

I would suggest, however, that the better plan in granting would be to award them for special rather than for general merits. Rules much more defined as they affect the conditions of reward should be laid down beforehand, and these rules should be compiled, or at least approved, by a committee of the trade whose performances are under judgment; for such a committee would know better than any stranger could do what was most sought after, what was most difficult of attainment in manufacture, and consequently most meritorious in accomplishment. For instance, adducing my own class as an example, there might be, I think, a gold medal for the cheapest

wine; another for that which showed the greatest properties—stability or "keeping;" a third for that possessing the finest flavour; a fourth for fulness of body; and an extraordinary medal—a jewelled or enamelled one, if that were thought expedient, for the wine combining in itself the greater number of the qualities mentioned above. These prizes might be limited to certain countries or districts, or, on the other hand, they might be thrown open to all the world. As the distribution of rewards is at present conducted, one exhibitor, we will say, obtains a gold medal for the perfection of his product, thus receiving the distinction which he deserved; but if to another exhibitor in the same class is awarded a precisely similar recognition, an appreciable injury must be done to the first-selected party. The distinctive value of the prizes given diminishes in a corresponding ratio to their augmentation in number, until, in the end, the first recipient becomes unpleasantly alive to the conviction that he would have been in a position as good, if not better, had no medals at all been awarded.

## Fine Arts.

The Bust of Beethoven.—There is no authentic bust or other portrait of Beethoven in existence, and a sculptor, M. Dantan, jun., set himself the difficult task of producing one. He collected all the existing pseudo-likenesses, consulted several persons who had known or seen the famous author of the "Pastoral Symphony," studied the man in his works and his biographies, and is said to have produced a most remarkable work, full of fire, genius, and character.

Competition for the Building of a Hôtel de Ville at Vienna.—The construction of a new Hotel de Ville in the capital of Austria has been decided on, and the municipal council has thrown the competition open to architects of all countries. The council, in order to reward as far as possible the labours of the competitors, has established twelve prizes, in three series of 2,500, 5,000, and 10,000 francs, which will be awarded for the most meritorious designs, by a jury nominated by the council, and consisting of five members of the council and five architects, Austrian or foreign, with the Burgomaster as president. The plans and specifications are to be seen at the Austrian consulate in Paris, and probably in London also.

Paris Academy of Beaux Arts.—M. Charles Blanc, author of very remarkable works on the fine arts, and formerly keeper of the Louvre, has been elected an honorary member of the academy, in the place of the late Count Walewski; Mr. Perkins, of Boston, has also been elected honorary corresponding member of the academy, in the place of the late Dr. Waagen, of Berlin.

## Manufactures.

Enamelling of Iron Vessels.—The enamelling of saucepans and other articles in wrought or cast iron has long been practised, a very fusible enamel reduced to powder being sprinkled over the surface of the iron when heated to redness, but as the mixtures employed consist of highly alkaline silicates the enamel is not very durable, and will not withstand acids or even salt liquids. An improved process has been introduced in France. The metallic surface is brought into contact with the ingredients of ordinary white glass, and heated to vitrification; the iron is said to oxidize by combination with silicic acid, and the glass thus forms one compact body with the metal. The coating of enamel may be laid on as thinly or thickly as desired, but a thin coating is better as regards the effect of expansion and dilatation. Experiments are being made in coating armour plates for ships in the manner above indicated.

## Commerce.

Trade of Buenos Ayres.—The government of Buenos Ayres has published a return of the trade and navigation of that country during the year ending the 12th September last. The entries amounted to 355,800 tons, of which 81,987 tons were under the English flag. The states which come next in order of importance are:—France, 62,073 tons; Italy, 49,900 tons; United States, 43,300 tons; and Spain, 39,800 tons. Of the French ports, Bordeaux and Bayonne figure for 25,727, Havre for 17,964, and Marseilles for 5,627. The clearings formed a total of 340,194 tons, of which, from want of return freights, 199,576 were in ballast. The proportion of English shipping was 86,000 tons, of which 38,000 were with cargoes; and of French vessels 60,800, or 49,000 with cargoes. In that respect the French shipowners were more highly favoured than the English. The chief imports into France from Buenos Ayres are to Havre; the principal markets for leather are in the United States and at Antwerp. That Belgian port received also the largest quantity of wool, the imports under that head amounting to 103,000 bales, or double the quantity sent to all France. The exports from Buenos Ayres, compared with the preceding year, show a considerable falling off. There is a decrease of 201,000 hides, 26,800 pipes and 22,500 casks of tallow, and 23,800 bales of wool. The Paraguayan war is the chief cause of this unfavourable position. The restoration of peace would, no doubt, produce a revival of affairs very necessary to the country, which requires a considerable export trade to balance the purchases she is making abroad.

The Adulteration of Wines.—Messrs. R. Symonds and Son, in their *Circular*, say:—"Practices of this description give rise to regrets that such punishment as was inflicted in the reign of Edward III. cannot now be enforced. In "Riley's Memorials of London and London Life in the 13th, 14th, and 15th Centuries" (recently published by order of the Corporation of London), it is stated that John Penrose, having sold red wine 'unsound and unwholesome for man, in deceit of the common people, and in contempt of our lord the King, and to the shameful disgrace of the officers of the City, to the grievous damage of the commonalty, &c,' was condemned to 'drink a draught of the same wine which he sold to the common people; the remainder of such wine shall then be poured on the head of the same John; and he shall forswear the calling of a vintner in the City of London for ever, unless he can obtain the favour of our lord the King as to the same.'"

Steam Ferry on the Lake Constance.—A steam ferry for carrying the railway across the Lake Constance between Freidrichshafen and Romanshorn is now about to be established; a gigantic pontoon has just been launched at Romanshorn for this purpose. It will be driven by steam, and carry sixteen railway carriages, and has been constructed by the well-known engineers of Zurich, Messrs. Escher, Wyn, and Company.

Lignite in Southern Italy.—Numerous traces of lignite are found in Southern Italy, but at present are but little worked, with the exception of some mines at Agnana, near Gerace, in Sicily, and at Gonidoni and Briatico, in Calabria. An important deposit has lately been discovered in the province of Benevento. This lignite is compact, of a brownish colour, and with a slight lustre. The bed, which varies from 20 to 30 centimetres (8 to 12 inches) in thickness, is upwards of 15 kilometres in length, and extends over an area of 150 square kilometres. A company is being formed for the purpose of working this bed. As compared with English coal, the price is in favour of the Benevento lignite, which can be obtained at 17 frs. per ton, whilst the former sells at Naples at from 40 to 45 frs. per ton. Other deposits of lignite are found in the province of Salerno, the most important being at Acerno, extending over 16 square

kilometres. In this bed there are five seams, one of which is 75 centimetres in thickness (2 feet 6 inches), and it is anticipated that under them seams of a greater thickness exist. In the Val d'Ofante also numerous traces of good lignite have been observed, but have not yet been explored.

Agricultural Exhibition at Savigliano.—The agricultural exhibition held from the 1st to 8th November, at Savigliano, in the province of Cuneo, has proved a complete success, and exceeded the expectations of the Comizio Agrario of that town by whom the arrangements were carried out. The total number of visitors during the eight days exceeded 1,500 persons. In the first division, which consisted of cereals, textiles, and plants for dyeing, woods, agricultural machines and implements, there were 103 exhibitors and 218 articles exhibited. The second division, comprising bullocks, heifers, and calves, numbered 34 exhibitors, and the number of head amounted to 84. The third division, consisting of flowers, shrubs, oils, wines, vinegar, spirits, &c., was most extensive, numbering 2,212 articles, and 475 exhibitors.

Russian Animal and Vegetable Productions.—A very curious notice of animal and vegetable productions in Russia, is given in a recent transaction of the Acclimatisation Society. It is remarked there, that in the North and Baltic provinces the bovine race have had for type the animals which Peter the Great had from Holland in the Government of Archangel, and that the race of horses is represented in three varieties. At the beginning of this century herds of wild horses were met with in the great prairies, which are overflowed in the spring by the Dnieper and its tributary, the Kouka. Fur animals constitute one of the riches of the country. In Siberia, certain tribes pay their taxes in skins of sable, ermine, blue fox, minever, &c. This tax in kind is the Emperor's private revenue, so that the most beautiful do not appear in the market. Russia furnishes annually in skins the amount of 80,000,000 francs.

## Colonies.

Statistics of Victoria.—According to the official returns the value of the imports and exports, at the port of Melbourne, up to the 3rd October of this year, is as follows:—Imports, £9,401,235; exports, £10,058,984. There is an increase in the value of imports of £1,909,888, and in the exports, of £1,660,876 over the returns of the year 1867. The amount of revenue received during the quarter ended 30th September was £830,846, against £895,901 during the corresponding period of last year; and for the nine months ended 30th September the revenue was £2,906,760, against £3,150,106 in 1867. The total receipts on the Victorian railways, during the year, up to 3rd October, have been £412,277, against £390,147 during corresponding period of 1867. The statement of the Melbourne and Hobson's Bay Company has been published, and the receipts, from July 1st to October 1st, amounted to £30,811 11s. 4d., against £30, 445 15s. 4d in 1867.

Railway Rolling Stock in New South Wales.—Since the first introduction of railways into the colony a large amount of rolling stock has been imported at a great expense, that might have been manufactured of as good quality, and as cheaply, or cheaper, in the colony. But now the Government invite tenders for the supply of the rolling stock of the railways for the next five years, either including the engines or not. This arrangement will enable colonial manufacturers to show what they can do, and it is expected that they will be found capable of competing favourably with the English manufacturers. The carriage-builders of the colony have already shown their ability to serve the public well.

## Notes.

Italian Mushrooms.—Mr. Story, in his account of the Piazza Navona, the principal market of Rome, makes the following mention of some of the fungi used in Italy for food:—"In the summer, as we pick our way along, we run constantly against great baskets of mushrooms. There are the grey *porcini*, the foliated *alberetti*, and the orange-hued *ovole;* some of the latter of enormous size, big enough to shelter a thousand fairies under their smooth and painted domes. In each of them is a cleft stick, bearing a card from the inspector of the market, granting permission to sell them; for mushrooms have proved fatal to so many Cardinals, to say nothing of Popes and other people, that they are naturally looked on with suspicion, and must all be officially examined to prevent accidents. The Italians are braver than we are in the matter of eating; and many a fungus which we christen with the foul name of toadstool, and ignominiously exile from our tables, is here baptised with the Christian appellation of mushroom, and is eagerly sought after as one of the cheapest and most delicious of vegetables."—*Story's "Roba di Roma."*

Agricultural Education in France.—The organization of theoretical education in agriculture and horticulture in all the primary normal schools of France is now under the consideration of the Minister of Public Instruction. It is proposed that a piece of ground be purchased or rented in the outskirts of each chief town of a department, to serve at once as a model farm for the farmers, and for the experiments and education of future agricultural and horticultural teachers. The expense will be met in the first instance by a grant from the State, to be eventually reimbursed by the departments.

Hop Leaves used as Fodder.—A farmer in the north of France writes to the *Gazette des Campagnes* that the scarcity of fodder having driven him to try to make use of whatever fell in his way in feeding his cattle, he found hop-leaves a valuable element of food for cows, when mixed with other things. He says that whenever he used the hop-leaves he always obtained more milk, and found his cows thrive better than usual. The leaves must be used soon after they are plucked, as the cows object to them when dried by the sun.

## Correspondence.

Industries and Prospects of Natal.—Sir,—On my return to London last night I found a copy of your *Journal*, of the 4th instant, awaiting me. Referring to the report of Dr. Mann's paper on the subject, and the discussion which arose thereon, I find some slight omissions to have been made, in what I am reported to have said, much calculated to mislead those who may read it. Will you kindly allow me space to correct, by supplying the few words left out, as they are very important. Commencing at line 70 is the following:—"The last speaker had stated the amount of capital required at £4,000, but he had planted 100 acres at a cost of £2,000, and fifty acres of it yielded at least forty tons per annum." It should read as follows:—"The last speaker had stated the amount of capital required at £4,000, but he had planted 100 acres at a cost *for planting* of £2,000. Fifty acres would yield this year; the *whole* would yield when in full bearing at least forty tons per annum." With regard to the price of money, I pointed out that twelve to fifteen per cent. per annum were common rates for borrowers to pay (as reported), but I also stated that such rates proved most ruinous to the borrower. Again at line 165:—"He never saw a starving man, or was asked for charity during his nineteen years' residence, except by a sailor." The following words were added but not reported:—"Or some person whose loose and bad habits had brought him to desti-

tution." There are one or two other slight errors, but as they are not important to the English public I will not remark on them. I shall feel obliged if you will publish this in your earliest number, as the statement with regard to the yield of coffee might deceive some intending emigrant or investor.—I am, &c., William Hartley.

19, Charterhouse-square, December 11th, 1868.

## MEETINGS FOR THE ENSUING WEEK.

Mon .....Society of Arts, 8. Cantor Lecture. Mr. W. H. Perkin' "On the Aniline or Coal Tar Colours."
Actuaries, 7. Mr. J. Coles, "On Railway Debenture Stock, considered as an Investment for the Funds of a Life Assurance Company."
Society of Engineers, 7½. Mr. Baldwin Latham, Continuation of paper on the "Application of Steam to the Cultivation of the Soil."
Medical, 8.
Asiatic, 3.
London Inst., 6.

Tues ...Civil Engineers, 8. Annual General Meeting.

Wed ...Society of Arts, 8. Mr. Henry Bryceson, "Description of the Electric Organ."
Geological, 8. 1. Mr. G. T. Clark, "On the Basalt-dykes of the Mainland of India." 2. Prof. W. King and Dr. T. H. Rowney, "On the so-called 'Eozoonal' Rock." Communicated by Sir R. I. Murchison, Bart. 3. Mr. T. W. Kingsmill, "Notes on the Geology of China." Communicated by the Assistant-Secretary. 4. Dr. Sutherland, "On the Auriferous Rocks of South-western Africa." With a Note by Sir R. I. Murchison, Bart.

## PARLIAMENTARY REPORTS.

### SESSIONAL PRINTED PAPERS.

Par. Numb. *Delivered on 1st August*, 1868.

440. East India (Army)—Statement.
458. Railway, &c., Bills—Return.
496. South Sea Islanders (Queensland)—Further Correspondence, &c.

*Delivered on 3rd August*, 1868.

Foreign Office Agencies—Further Papers.

*Delivered on 5th August*, 1868.

277. (I.) Shannon River—Index to Report.
348. (I.) Ecclesiastical Titles in Great Britain and Ireland—Index to Report.
384. The Finance Accounts (Great Britain and Ireland)—Parts I. to VII.
425. Grand Jury Presentments (Ireland)—Abstract of Accounts.
427. East India (Oriental Steam Company)—Correspondence.
482. Convicts (Fremantle)—Extracts of Letter.
455. Distillers, &c.—Return.
490. Constabulary (Cornwall)—Return.

*Delivered on 6th August*, 1868.

486. Police Systems (Scotland)—Lords' Report.
Public Petitions—Supplement to the Thirty-second Report.

*Delivered on 8th August*, 1868.

203. (6.) Railways Abandonment—Warrant.
203. (7.) Railways Abandonment—Warrant.
403. Postal Communication (Australia)—Correspondence.
439. Queen Anne's Bounty Board—Report and Evidence.
456. Labouring Classes' Dwelling Houses Act (1866)—Return.
480. Public Statues—Return.
492. Friendly Societies (Ireland)—Report.
East India Railways—Report.
Convict Establishments (Western Australia and Tasmania)—Annual Reports.
Post Office—Fourteenth Report of the Postmaster General.
Public General Statues—Cap. 64 to 130.

*Delivered on 24th August*, 1868.

151. (v.) Trade Accounts (Foreign Countries)—Belgium, Holland, France, and United States.
232. Industrial and Provident Societies—Return.
307. (I.) Lee River Conservancy Bill—Index to the Report.
310. (I.) Local Courts of Civil Jurisdiction—Return.
388. Revenue (Ireland)—Return.
421. County Financial Arrangements—Report and Evidence.
437. East India (Electric Telegraphs)—Return.
444. Naval Savings Banks—Account.
445. Poor Law (In-door Poor)—Returns.
447. Weights and Measures—Second Report of the Warden.
460. Income and Property Tax—Return.
467. Army and Navy Estimates—Account.
468. Isle of Man—Account.
488. Fortifications—Account.
491. Thames Conservancy—General Report.
499. Dogs Regulation (Ireland) Act (1865)—Annual Account.
Exchequer Standards—First Report of the Commissioners.
Marriage Laws—Report of the Commissioners.

Session, 1867.

431. (C. I.) Poor Rates and Pauperism—Return (C).

*Delivered on 27th August*, 1868.

256. Bill—Prisons (Ireland).
Public General Statutes—Table.
North America (No. 2, 1868)—Correspondence.

*Delivered on 29th August*, 1868.

104. (I.) Weights and Measures (Metropolis)—Return.
232. (I.) Industrial and Provident Societies—Return.
334. Telegraphic Communication (East India)—Correspondence.
435. (I.) Electric Telegraphs Bill—Index.
452. Public Accounts—Report.
462. Inland Revenue (Defalcations)—Return.
475. Greenwich Hospital—Accounts.
498. Standing Orders of the House of Commons (1867-8).

*Delivered on 3rd September*, 1868.

119. (VI.) Trade and Navigation Accounts (31st July, 1868).
350. Court of Probate—Account.
398. Aliens—Returns.
441. Married Women's Property Bill—Report and Evidence.
487. Houses of Parliament—Report.
502. Mountjoy Convict Prison—Correspondence.

*Delivered on 9th September*, 1868.

280. (I.) Sale of Liquors on Sunday (Ireland) Bill—Index to the Report.
344. (A. II.) Poor Rates and Pauperism—Return (A).
354. (I.) Bank Holidays Bill—Index to the Report.
372. (I.) Bristol Election Petition—Index.
393. Extradition—Report and Evidence.
401. Special and Common Juries—Report and Evidence.
432. Scientific Instruction—Report and Evidence.
439. (I.) Queen Anne's Bounty Board—Index.
446. County Surveyors, &c. (Ireland)—Return.
470. Navy (Coating of Ships)—Returns.
483. British Columbia - Correspondence.
505. Highways Act—Return.

*Delivered on 12th September*, 1868.

402. Sale of Liquors on Sunday Bill—Special Report and Evidence.

*Delivered on 14th September*, 1868.

151. (VI.) Trade Accounts (Foreign Countries)—Belgium, Holland, France, and United States.
Poor Law—Twentieth Annual Report.

*Delivered on 18th September*, 1868.

393. (I.) Extradition—Index to the Report.
408. "Garonne" Steamer—Evidence
420. Malt Tax—Report and Evidence.
469. Admiralty Monies and Accounts—Report and Evidence.
481. Committees—Return.
503. Shoeing Horses—M. Charlier's System.
504. Army and Navy Chaplains—Return.

*Delivered on 23rd September*, 1868.

Established Church (Ireland)—Report of the Commissioners.

*Delivered on 26th September*, 1868.

392. Grand Jury Presentments (Ireland)—Report.
400. Savings Banks—Return.
407. Merchant Ships—Correspondence.
423. Import and Export Duties (Foreign Countries)—Return.
476. Constabulary (Ireland)—Returns.
479. New Forest Deer Removal Act, 1851—Report, Evidence, &c.

*Delivered on 2nd October*, 1868.

119. (VII.) Trade and Navigation Accounts (31st August, 1868).
342. Poor Rates Assessment, &c.—Report.
397. Friendly Societies—Report of Registrar.

*Delivered on 7th October*, 1868.

International Coinage—Report and Evidence.

*Delivered on 10th October*, 1868.

406. Merchant Shipping—Return.
429. Steam Vessels - Return.
450. Joint Stock Companies—Return.
463. Taxes and Imposts- Return.
486. (I.) Police Systems (Scotland)—Index.

*Delivered on 21st October*, 1868.

151. (VII.) Trade Accounts (Foreign Countries).
Trade Unions and other Associations—Tenth Report.

*Delivered on 23rd October*, 1868.

170. (I.) Navy (Health)—Statistical Report.
344. (A. III.) Poor Rates and Pauperism—Return (A.).
420. (I.) Malt Tax—Index to the Report.
421. (I.) County Financial Arrangements—Index.
433. Endowed Charities (County of Bedford)—General Digest.

*Delivered on 26th October*, 1868.

Colonial Possessions—Statistical Tables, Part XII.

*Delivered on 30th October*, 1868.

119. (VIII.) Trade and Navigation Account (30th September, 1868).
465. Treasure Trove—Returns.
Trade and Navigation—Annual Statement.

Session 1867.

119. (E.) Poor Rates and Pauperism—Return (E.).

*Delivered on 6th November*, 1868.

Civil Service—Thirteenth Report of the Commissioners.

*Delivered on 10th November*, 1868.
344. (A. IV.) Poor Rates and Pauperism—Return (A.)
477. Orders of Removal—Return.
493. Civil Contingencies Fund—Accounts.

*Delivered on 13th November*, 1868.
Public Reports—Index to Reports.

*Delivered on 16th November*, 1868.
244. Bill—Tenure and Improvement of Land, &c. (Ireland).

*Delivered on 23rd November*, 1868.
Agriculture—First Report of the Commissioners.

*Delivered on 24th November*, 1868.
151. (VIII.) Trade Accounts (Foreign Countries).
401. (I.) Special and Common Juries—Index to Report.
457. Foreshores—Treasury Warrant.
469. (I.) Admiralty Monies and Accounts—Index to Report.
495. Foreign Seamen and Apprentices—Return.

*Delivered on 28th November*, 1868.
359. Newspapers—Return.
433. (I.) Endowed Charities—General Digest.
484. Railways—Returns.
Agriculture—Appendix, Part II. to First Report.

*Delivered on 2nd December*, 1868.
119. (IX.) Trade and Navigation Accounts (31st December)
416. Electric Telegraphs—Return.
485. Railways—Return.
505. Highways Act—Return.

*Delivered on 11th December*, 1868.
417. Merchant Shipping—return.
472. Vessels not Armour-plated—Return.
474. Navy (First-class Boys, &c.)—Return.

*Delivered on 12th December*, 1868.
251. Pilotage—Return.
344. (A. V.) Poor Rates and Pauperism—Return (A).

## Patents.

*From Commissioners of Patents' Journal, December* 11.

GRANTS OF PROVISIONAL PROTECTION.

Alkali, recovery of, from solutions used in paper making—3504—F. O. Ward, W. Ibotson, and A. G. Southby.
Arm protectors—3586—D. S. Merry.
Atmospheric hammers for crushing ores, &c.—3573—H. E. Newton.
Bells, suspending—3533—G. Eguillon.
Bird cages, &c.—3588—G. Baker, jun.
Boilers—3592—E. T. V. Heeke.
Boilers, applying heat to—3593—N. D. Spartali.
Bottles, &c., securing the contents of—3655—J. B. Shillcock.
Buckles—3595—H. Milsted.
Buildings, heating—3612—A. Harris.
Carding engines, &c.—3513—S. Crighton and J. Taft.
Carpets—3614—J. S. Templeton.
Carts, &c., for removing snow—3522—E. H. Bayley.
Cast-iron, treating—3634—J. Heaton.
Cigars—3584—W. R. Lake.
Dyeing and printing—3633—J. L. Norton.
Felted fabrics, manufacturing—3560—W. E. Newton.
Fences—3572—W. Dinwoodie.
Fire-arms—3601—P. Panton.
Fire-arms, breech-loading—3608—H. Pollack.
Fire-arms, breech-loading—3637—W. Soper.
Fire-arms, &c., breech-loading—3622—W. Tranter.
Flowers, &c., preserving—3632—J. Saward.
Games, apparatus to be used in playing—3591—H. Smith.
Gas burners, apparatus to be employed for exhibition purposes in connection with—3477—H. Carter.
Gas regulators, &c.—3581—G. Bernhardt.
Gearing for multiplying motion on a single shaft—3574—H. E. Newton.
Harness, &c.—3364—J. Edwards.
Harvesting machines—3610—W. R. Lake.
Hats—3645—J. Myers and L. L. Morrison.
Haymaking machines—3458—W. N. Nicholson.
Horse collars—3302—C. Kelson.
Hydraulic motive-power—3599—L. Roman.
Indigo blue, &c.—3583—P. Spencer.
Kilns for burning bricks, &c.—3426—G. Wilson, sen., and J. Wilson, jun.
Kilns for burning bricks, &c.—3461—W. Harrison.
Lace machinery, manufacture of fabric in—3530—W. Brookes.
Laces and braids, machinery for making—3606—A. Büsche.
Letter or paper clips—3621—A. M. Clark.
Looms—3585—S. Brook and C. Thompson.
Looms—3611—J. H. Moreland and J. Coulong.
Looms—3620—J. H. Dales and J. F. Maygrove.
Lubricators—3619—W. E. Newton.
Meteorological indicators—3576—B. Solomons.
Motive-power—3555—W. H. Ibbett.
Motive-power—3594—J. Bourne.
Motive-power engines—3580—W. Wild.
Needles, threading—3598—E. Ellenband.
Needles, &c., winder for packing up—3384—M. B. Westhead and C. B. James.
Packing-cases—3587—W. F. Chapman.
Paddle wheels—3609—W. R. Lake.
Palm nuts, &c., machine for cracking—3625—A. Wyllie & J. Latham.
Paper tubes, manufacturing—3553—C. Crabtree and J. Stell.
Pencils for marking linen, &c.—3415—J. Hickisson.
Plate-warming apparatus—3630—W. E. Gedge.
Plough heads, &c., casting—3643—D. Greig and J. Fernie.
Pottery, &c., preparing materials used in manufacturing—3639—J. S. Forbes.
Pressure gauges—3626—H. J. H. King.
Printing machines—3430—A. M. Clark.
Railway trains, communication in—3570—W. Carter.
Railway trains, signalling on—3575—E. R. Wethered.
Railways—3605—C. E. Spooner and G. A. Huddart.
Railways, receiving and delivering mail bags and packages on—3649—A. V. Newton.
Ratchet braces, &c.—3603—J. Sincock.
Reaping and mowing machinery—3615—A. C. Bamlett.
Reaping and mowing machines—3627—J. Cornes.
Sad-irons, &c.—3596—W. R. Lake.
Scarfs, &c., fastening—3597—D. Vogl.
Sea walls and breakwaters—3571—T. Prideaux.
Sewage, utilising—3562—T. Smith and J. V. N. Bazalgette.
Sewing machines—3564—J. E. Phillips.
Sewing machines—3659—H. W. Fuller and I. W. Barnum.
Ships—2864—A. F. Campbell.
Ships, iron, protecting from corrosion, &c.—3226—C. MacMillan.
Shirt-front and collar combined—3657—E. Price.
Silk, &c., washing and dyeing—3618—T. and A. L. Dickins and H. Heywood.
Slide valves—3568—W. G. Beattie.
Springs used for upholstery purposes—3578—J. Parry.
Steam engines—3600—F. Holt.
Steam engines, condensers for—3550—I. Hudson.
Steel—3631—C. D. Abel.
Stone, &c., dressing, &c.—3607—E. T. Hughes.
Superphosphate of lime—3624—E. S. Samuell.
Tortion springs—3342—B. Johnson.
Tug boats—3589—W. E. Gedge.
Umbrellas, &c.—3434—A. A. Hely.
Vegetable fibre, bleaching—3647—J. W. Reid.
Warp-dressing machinery—3623—J. Ingham and I. Butterfield.
Watches—3577—B. Hunt.
Windows, &c., hanging and supporting—3582—T. Craig.
Wool, &c., washing and dyeing—3617—J. Petrie, jun.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

Gas, manufacturing, &c.—3715—A. B. Bérard.
Railway carriage wheels—3723—W. R. Lake.

PATENTS SEALED.

1922. J. Gray and R. Weir.
1933. J. Toft.
1938. J. Howden.
1941. J. T. Parlour.
1942. T. H. P. Dennis.
1949. F. Worcester.
1953. C. Humfrey and W. S. Webster.
1956. W. and O. Brooke.
2051. C. Hastings, J. Briggs, and J. Law.
2004. S. Bowen, C. Glover, R. H. Davis, T. Stanford, T. Scott, A. M. Bell, E. Sheldon, W. Farmer, L. Maskall, E. Colburn, and J. C. Cole.
2057. S. S. Maurice.
2068. C. Mather.
2830. C. D. Abel.
2942. C. E. Brooman.

*From Commissioners of Patents' Journal, December* 15.

PATENTS SEALED.

1702. J. S. Richard.
1957. W. Rowan.
1965. G. B. Turrell.
1967. T. Comfield, jun.
1968. J. McLeod.
1971. W. and J. Rhodes.
1974. J. and E. Lumley.
1976. A. Cochran.
1979. T. C. Hide.
1980. C. Hengst and H. Watson.
1982. J. Hemington.
1985. J. Perry.
1986. D. and J. Greig.
1988. M. P. W. Boulton.
1989. F. B. Dœring and R. H. Twigg.
1990. A. J. B. P. Thierry.
1991. T. Heppell.
1998. J. Hadley.
2001. J. Bonnall.
2002. J. Shelmerdine, W. Walker, and E. Holt.
2020. J. and A. Douglas.
2029. B. T. Moore.
2037. M. and J. Mackie.
2049. G. T. Bousfield.
2060. F. H. Holmes.
2067. I. Baggs and F. Braby.
2075. J. Morris.
2122. J. H. Johnson.
2126. J. H. Johnson.
2262. T. Kendrick and S. Davies.
2564. W. E. Newton.
2810. H. B. Woodcock.
3017. W. R. Lake.
3086. J. Dewar.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

3183. E. Morewood.
3185. R. F. Fairlie.
3208. C. K. Tomlinson and C. J. Hayward.
3239. H. W. Miller.
3357. C. F. Varley.
3281. W. E. Newton.
3297. W. F. Cooke & G. Hunter.
3223. G., E., and A. A. Atkin.
3250. C. Blyth.

PATENT ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

3130. T. Walker.